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Crivella et al.

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(54) **SYSTEMS AND METHODS FOR AIRCRAFT STRUCTURE SURFACE COVERS**

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(52) **U.S. Cl.**
CPC ***B64C 23/005*** (2013.01)

(58) **Field of Classification Search**
CPC B64C 23/005; B64C 2230/26
See application file for complete search history.

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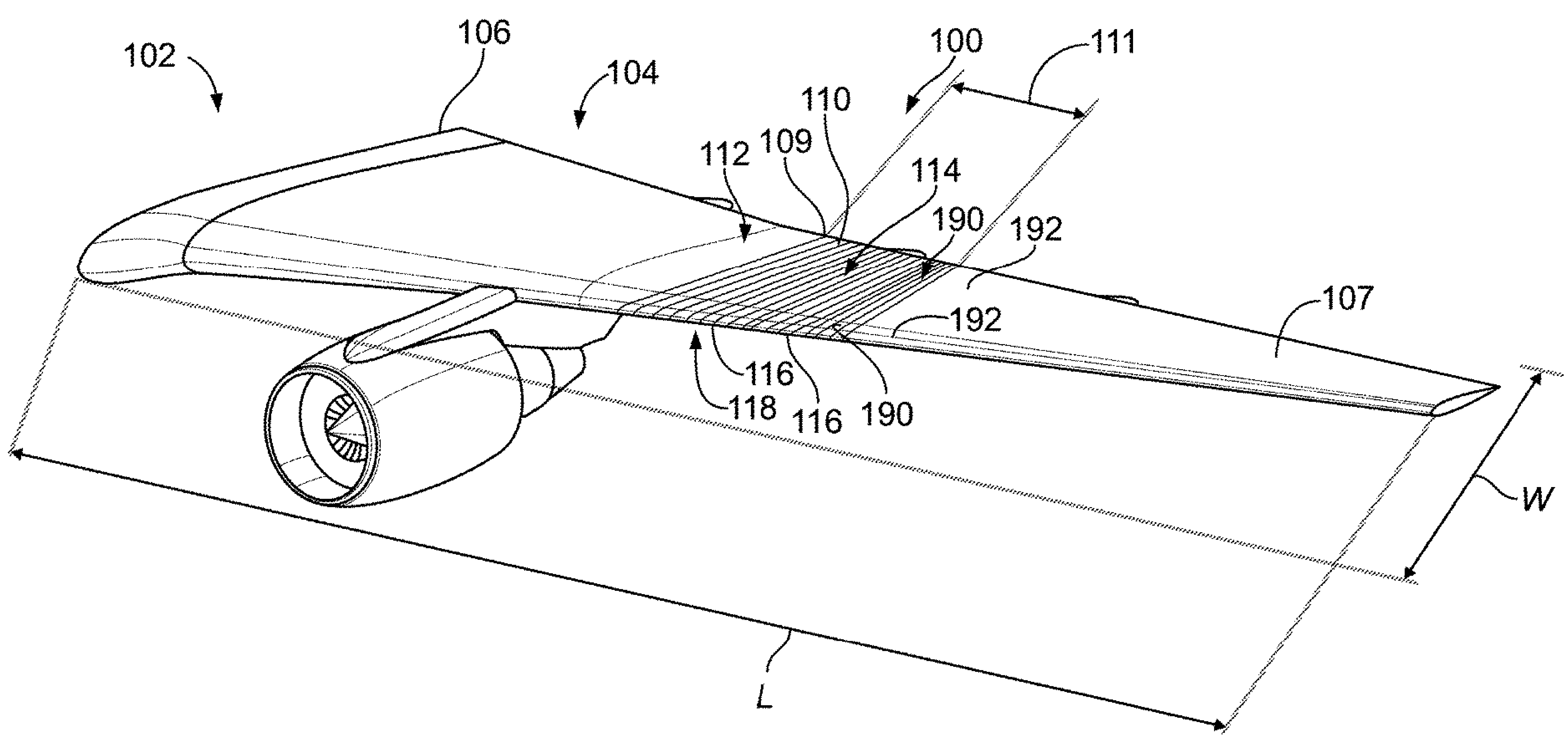
(57) **ABSTRACT**

An aircraft surface cover is provided. The aircraft surface cover includes a cover member that is configured to be removably secured to an aircraft structure. The cover member includes an exterior surface that has a microtextured surface including microtexture ribs that are configured to improve aerodynamic performance of the aircraft structure.

21 Claims, 8 Drawing Sheets



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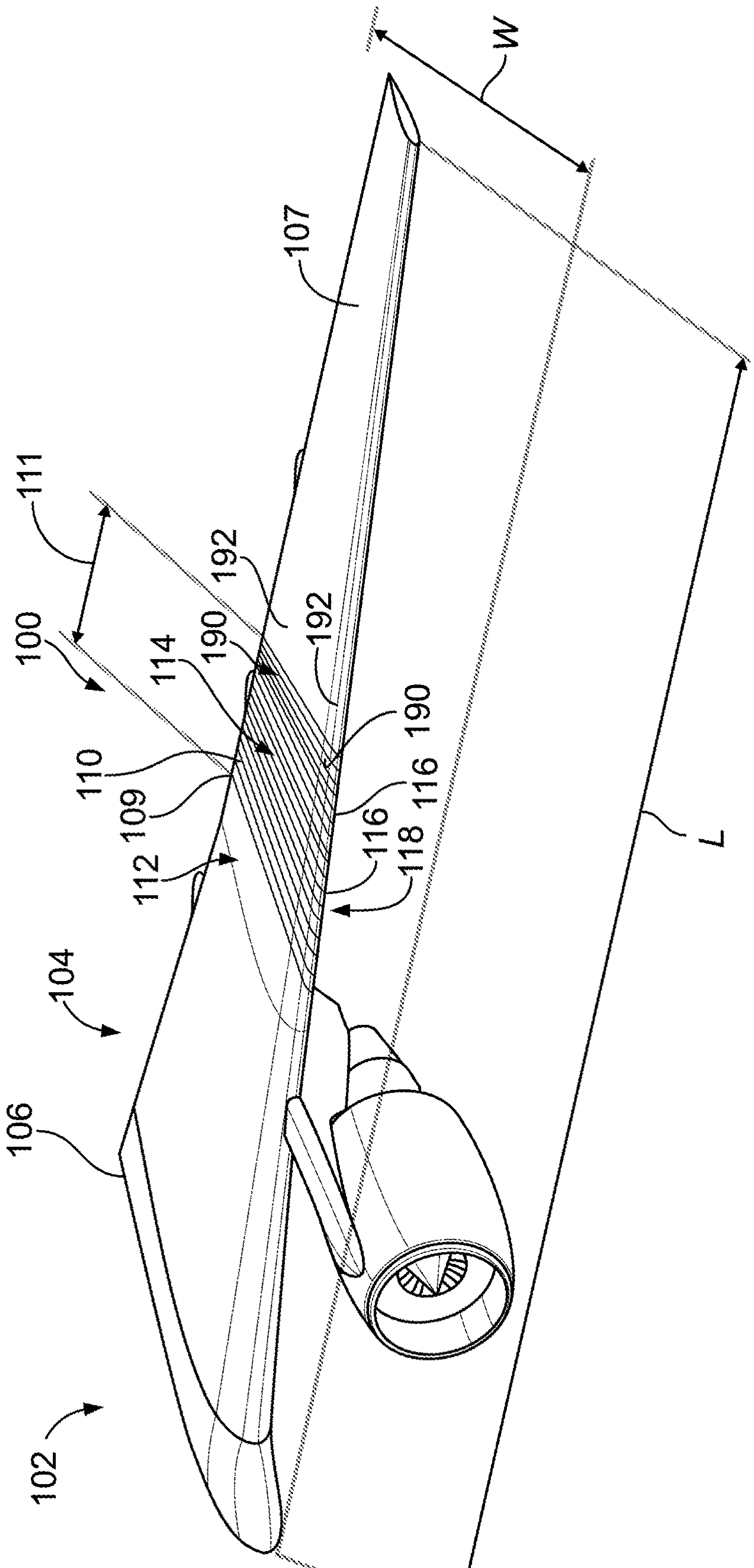
W
107
111
192
192
100
190
114
190
110
109
116
116
116
118
112
104
106
102
L

FIG. 1

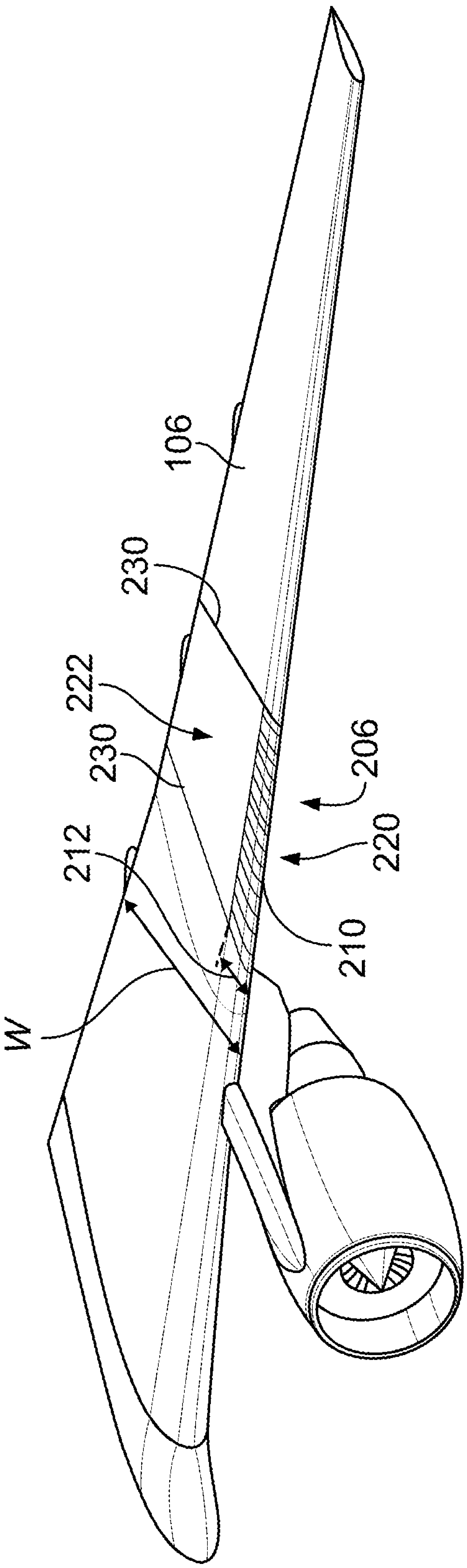

FIG. 2

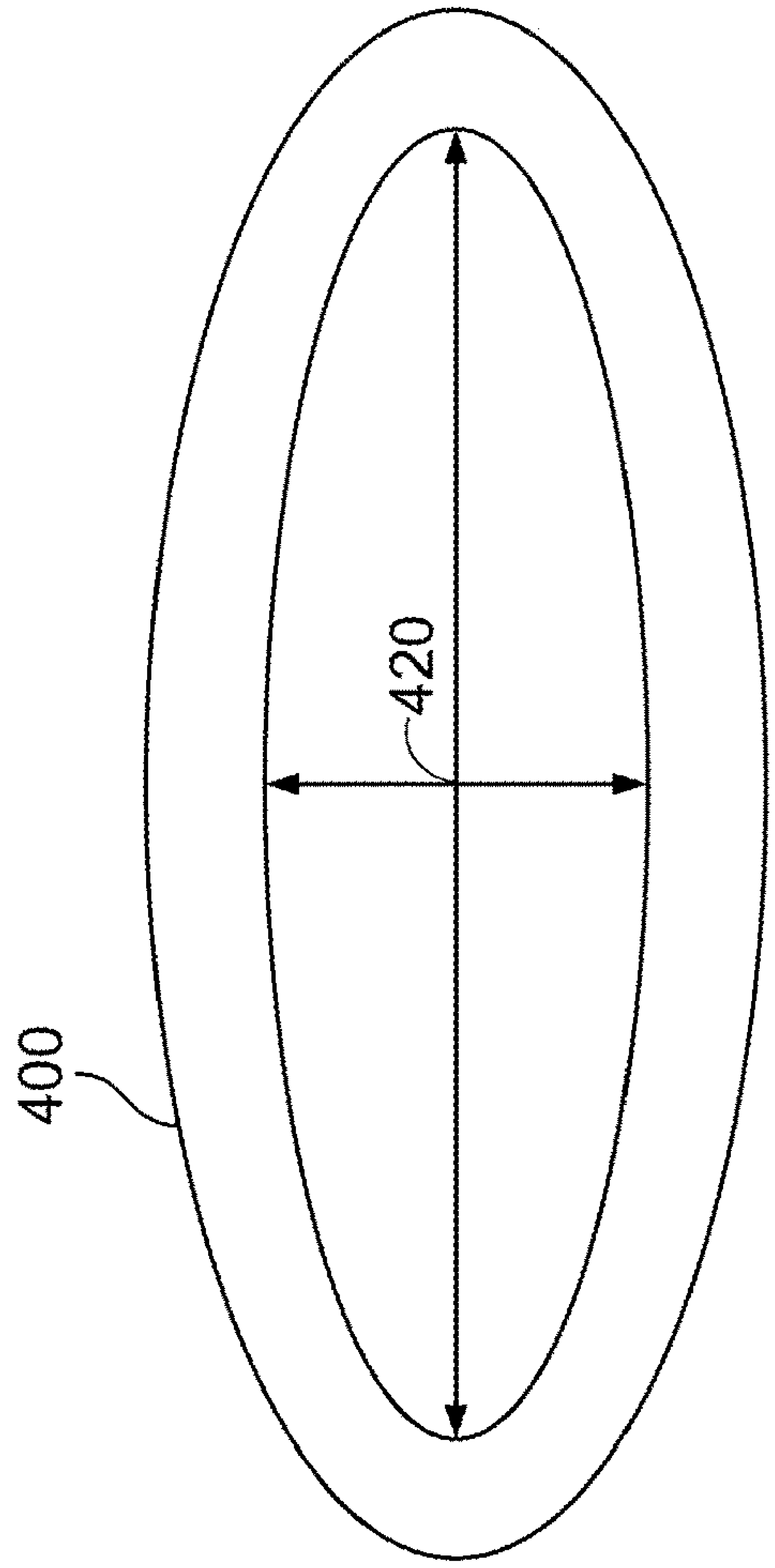

FIG. 4

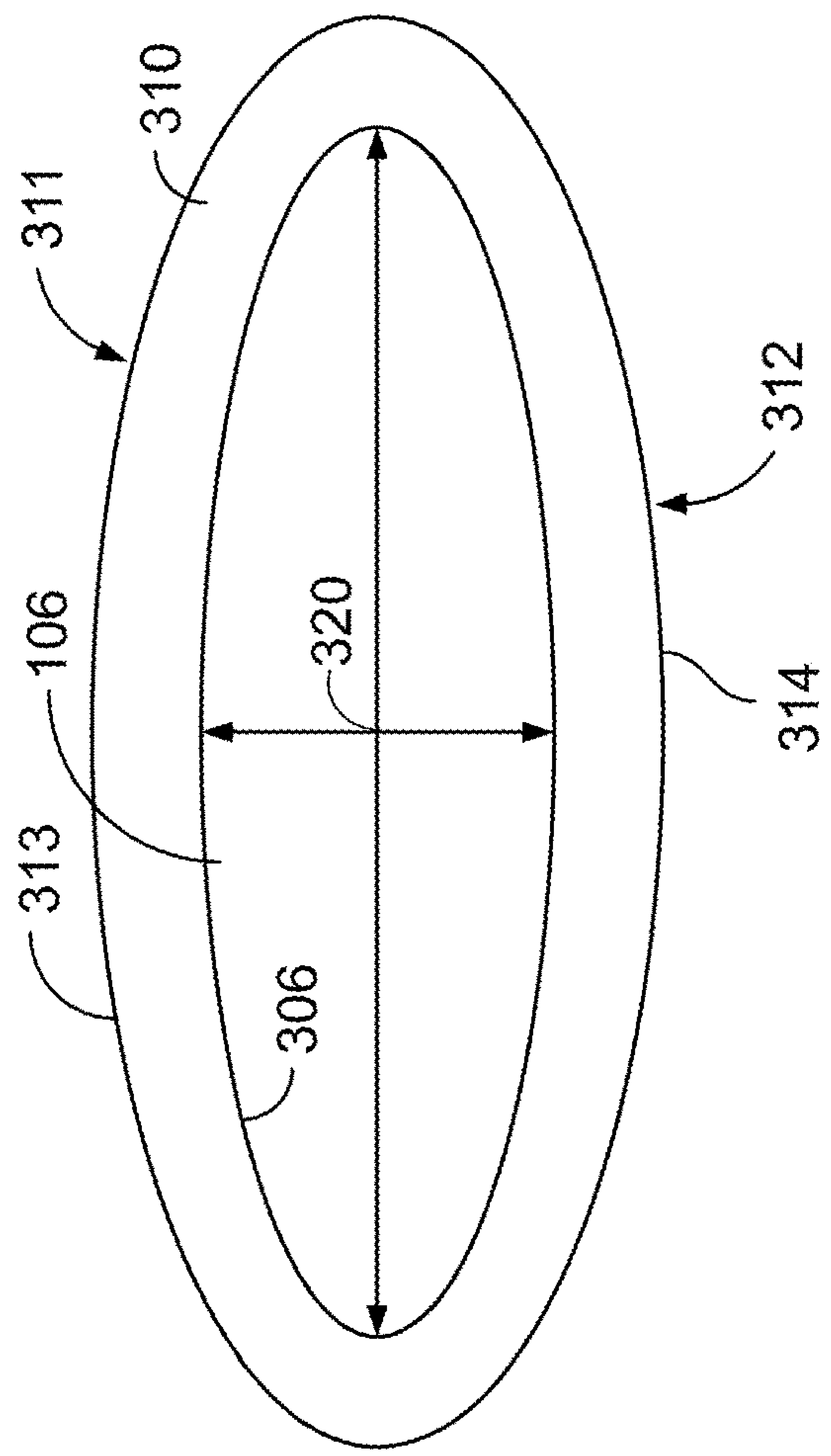

FIG. 3

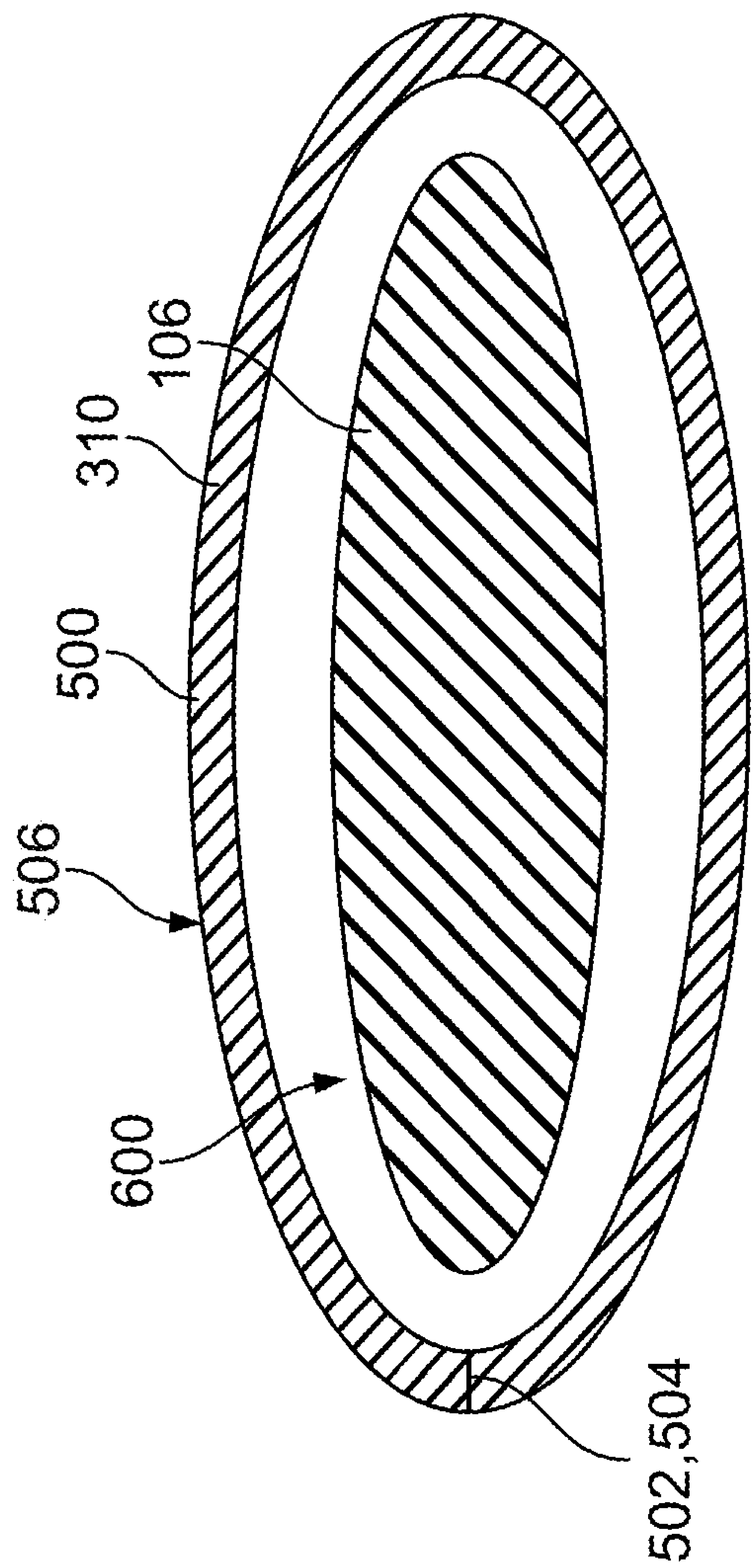

FIG. 6

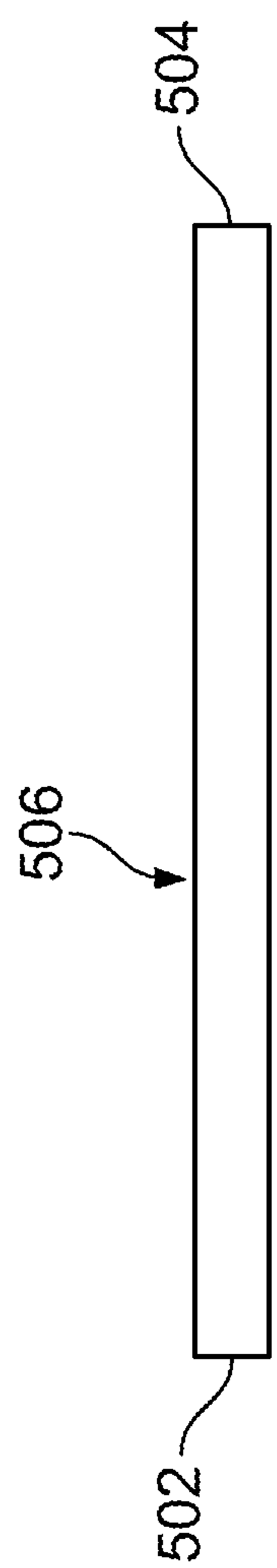

FIG. 5

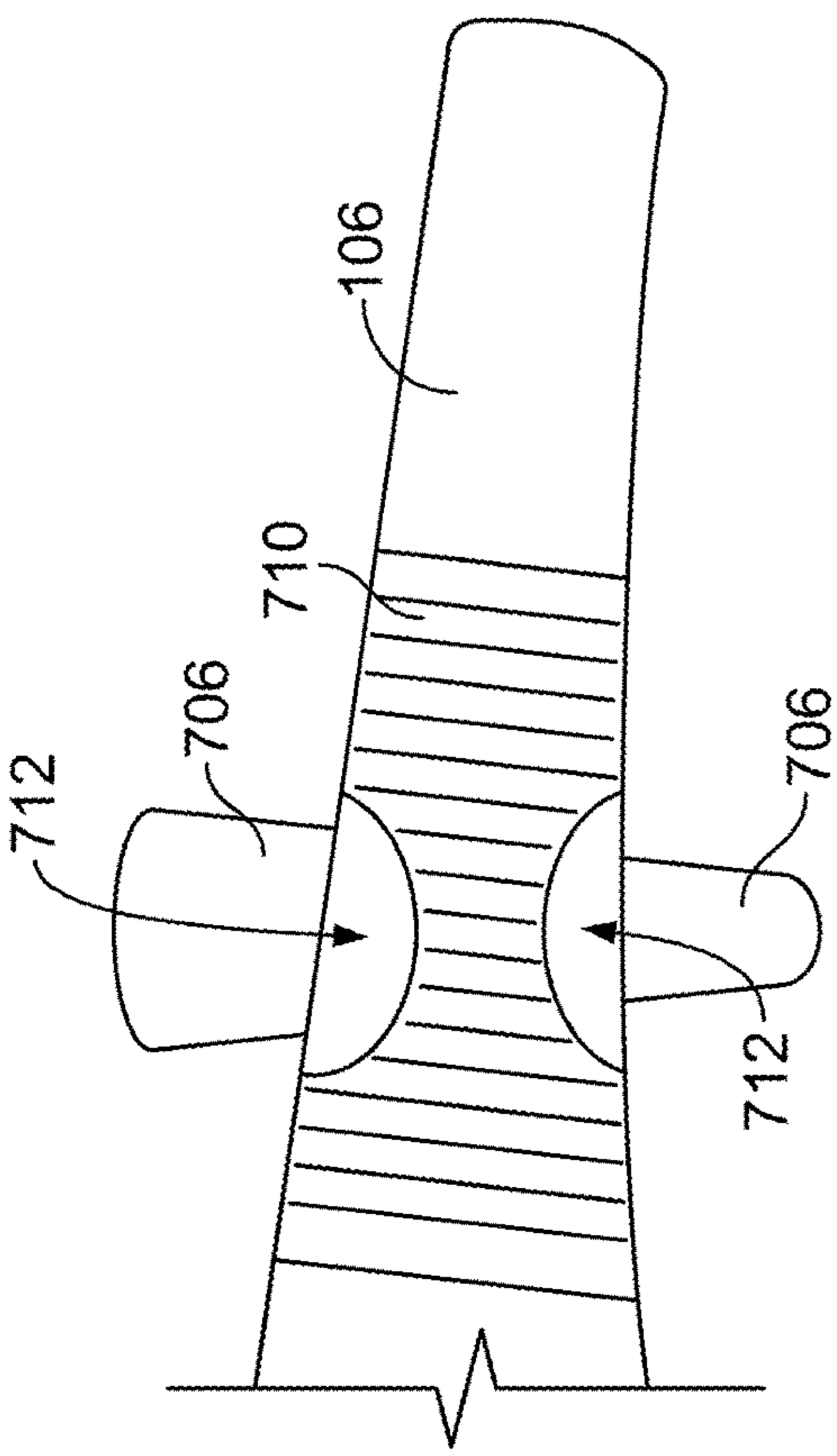

FIG. 7

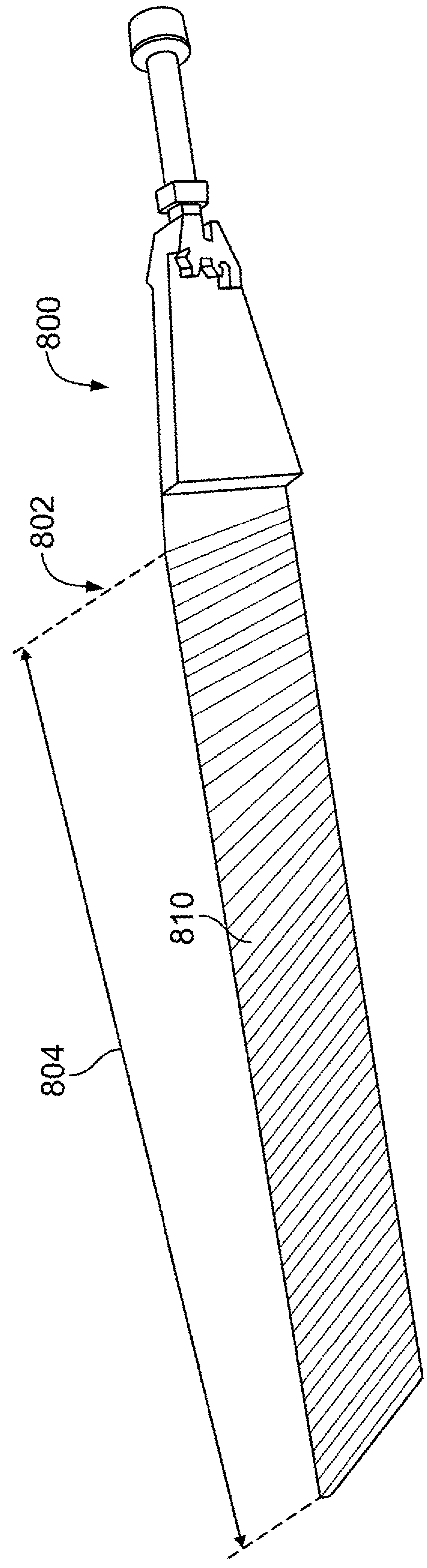

FIG. 8

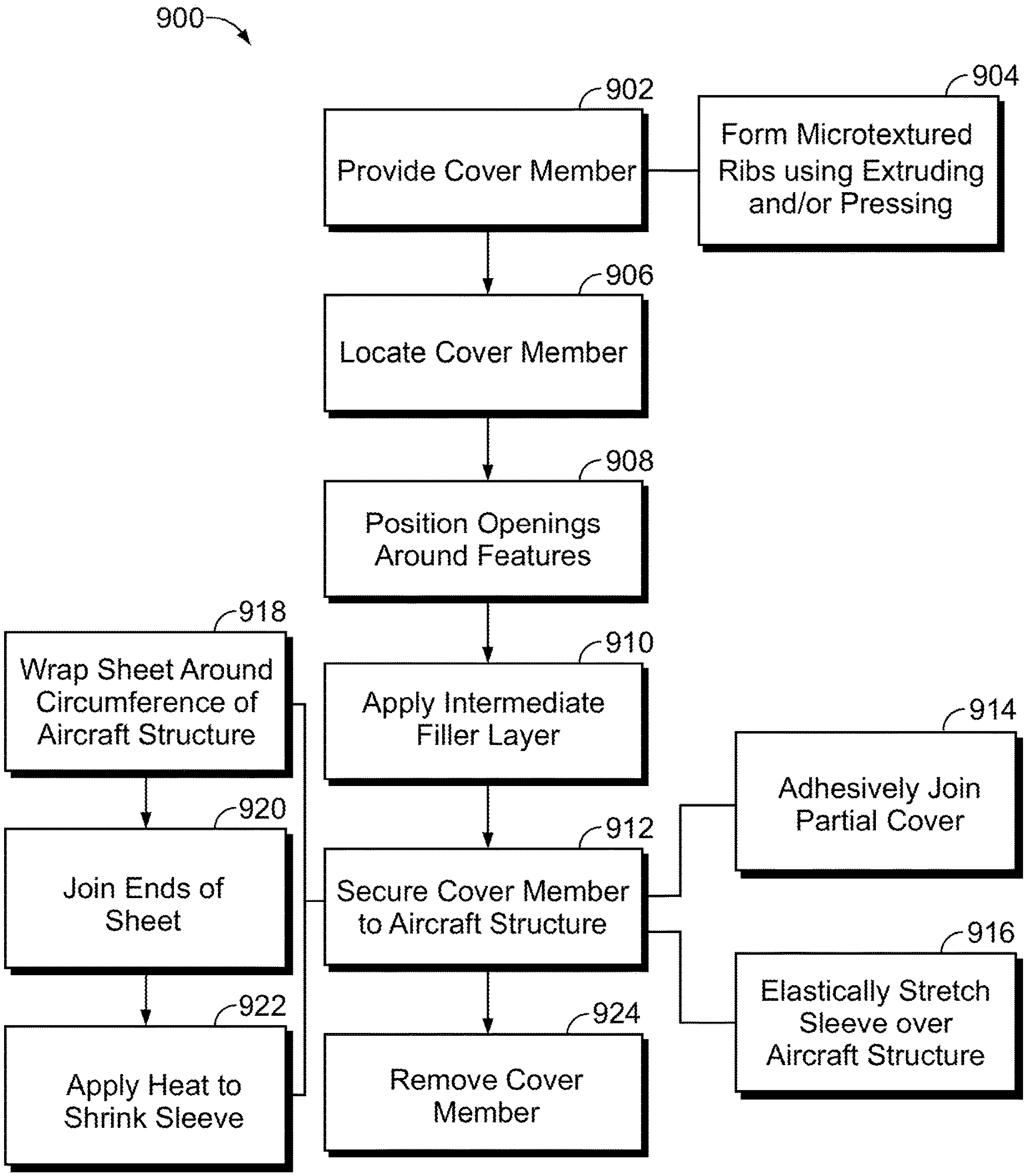
900
902
Provide Cover Member
904
Form Microtextured Ribs using Extruding and/or Pressing
906
Locate Cover Member
908
Position Openings Around Features
910
Apply Intermediate Filler Layer
912
Secure Cover Member to Aircraft Structure
914
Adhesively Join Partial Cover
916
Elastically Stretch Sleeve over Aircraft Structure
918
Wrap Sheet Around Circumference of Aircraft Structure
920
Join Ends of Sheet
922
Apply Heat to Shrink Sleeve
924
Remove Cover Member

FIG. 9

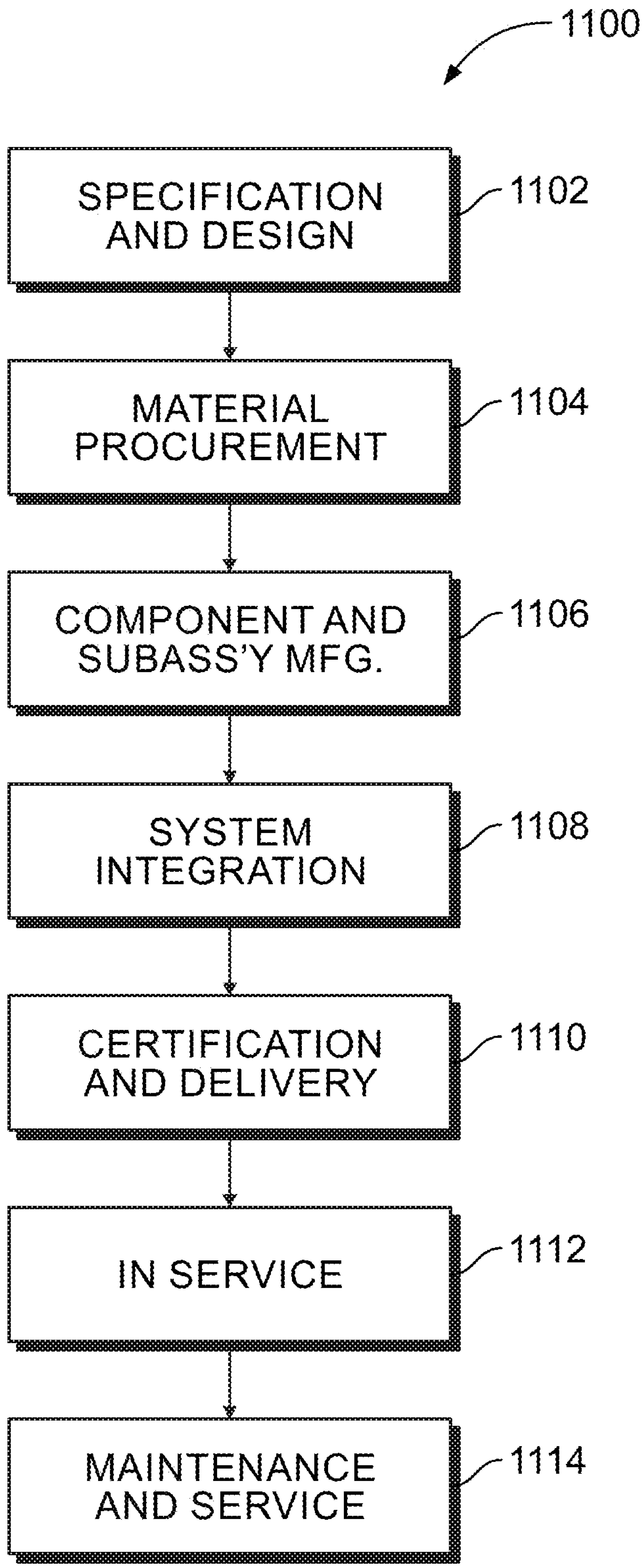
1100
SPECIFICATION AND DESIGN
1102
MATERIAL PROCUREMENT
1104
COMPONENT AND SUBASS'Y MFG.
1106
SYSTEM INTEGRATION
1108
CERTIFICATION AND DELIVERY
1110
IN SERVICE
1112
MAINTENANCE AND SERVICE
1114

FIG. 10

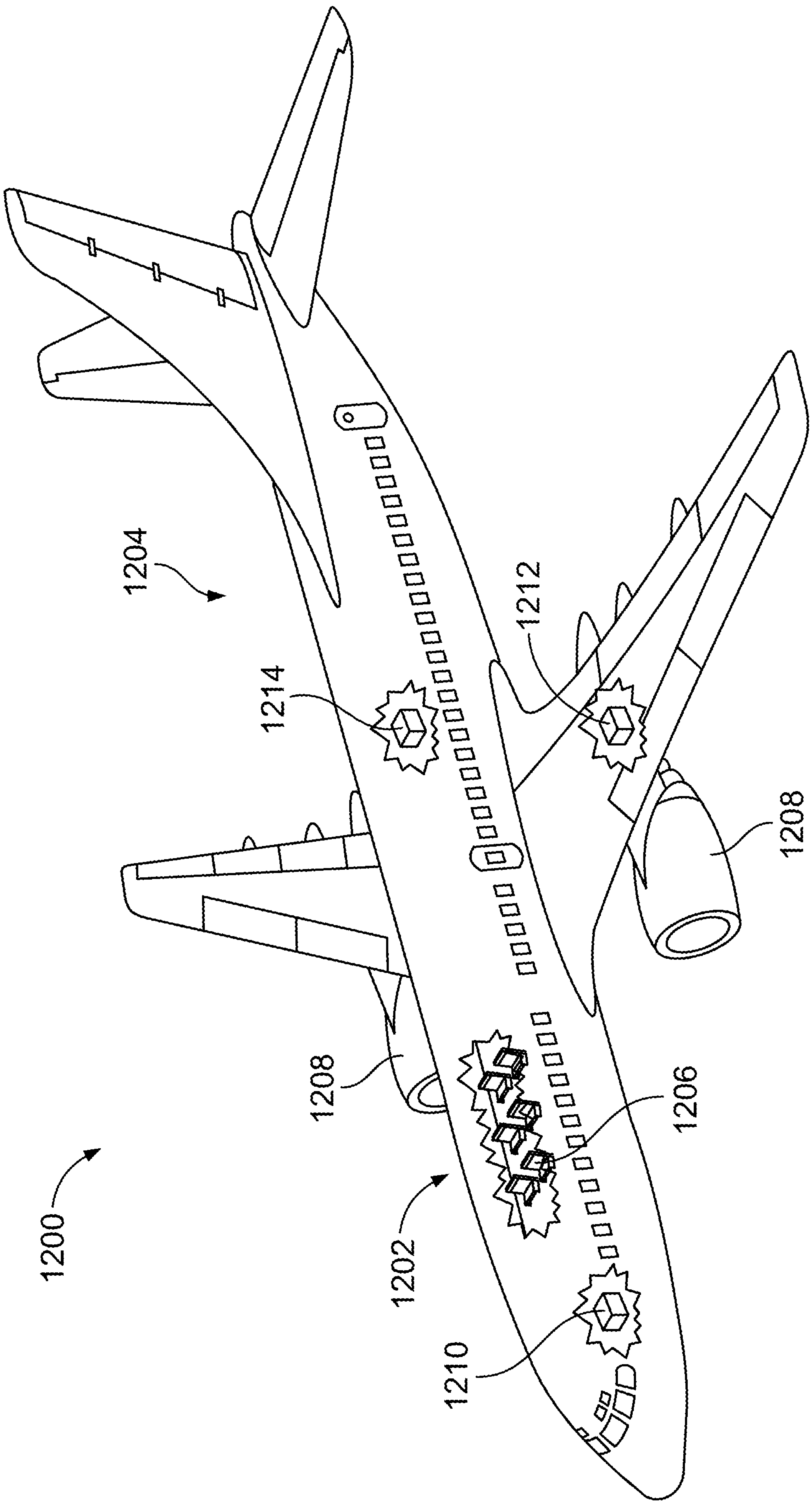

FIG. 11

SYSTEMS AND METHODS FOR AIRCRAFT STRUCTURE SURFACE COVERS

FIELD OF THE DISCLOSURE

Examples of the present disclosure generally relate to systems and methods for providing microtextured surfaces for aircraft structures.

BACKGROUND OF THE DISCLOSURE

Microtextured skin patterns may be utilized on airfoil surfaces to improve aerodynamic properties (e.g., drag and/or lift). However, such skin patterns may be difficult or expensive to manufacture, install, and/or maintain.

For example, use of machining or other means of subtracting from an airfoil surface (e.g., laser ablation, etching) may reduce durability of the airfoil, and may result in expensive and/or inconvenient repair and/or installation. As another example, techniques such as hot metal rolling or pressing may distort the surface, and also result in expensive and/or inconvenient repair and/or installation.

SUMMARY OF THE DISCLOSURE

A need exists for an improved system and an improved method for providing microtextured surfaces to airfoil surfaces.

With those needs in mind, certain examples of the present disclosure provide an aircraft surface cover. The aircraft surface cover includes a cover member that is configured to be removably secured to an aircraft structure. The cover member includes an exterior surface that has a microtextured surface including microtexture ribs that are configured to improve aerodynamic performance of the aircraft structure.

Certain examples of the present disclosure provide a method of improving aerodynamic performance of an aircraft structure. The method includes providing a cover member comprising an exterior surface that has a microtextured surface. The microtextured surface includes microtexture ribs configured to improve aerodynamic performance of the aircraft structure. The method also includes securing the cover member to the aircraft structure.

Certain examples of the present disclosure provide an aircraft assembly that includes an aircraft structure and a cover member. The aircraft structure is disposed on an exterior of an aircraft. The cover member is removably secured to the aircraft structure, and includes an exterior surface. The exterior surface has a microtextured surface that includes microtexture ribs that are configured to improve aerodynamic performance of the aircraft structure.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates a perspective view of an aircraft assembly, according to an example of the present disclosure.

FIG. **2** provides a perspective view of a partial cover disposed on an aircraft structure, according to an example of the present disclosure.

FIG. **3** provides a cross-sectional view of a sleeve disposed around a circumference of an aircraft structure, according to an example of the present disclosure.

FIG. **4** provides a side view of an elastic sleeve, according to an example of the present disclosure.

FIG. **5** provides a side schematic view of a sheet used to form a sleeve, accordingly to an example of the present disclosure.

FIG. **6** provide side schematic view of the sheet of FIG. **5** formed into a sleeve.

FIG. **7** provides a schematic view of a sleeve, according to an example of the present disclosure.

FIG. **8** provides a schematic view of a sleeve, according to an example of the present disclosure.

FIG. **9** provides a flowchart of a method, according to an example of the present disclosure.

FIG. **10** is a block diagram of aircraft production and service methodology.

FIG. **11** is a schematic perspective view of an aircraft.

DETAILED DESCRIPTION OF THE DISCLOSURE

The foregoing summary, as well as the following detailed description of certain examples will be better understood when read in conjunction with the appended drawings. As used herein, an element or step recited in the singular and preceded by the word "a" or "an" should be understood as not necessarily excluding the plural of the elements or steps. Further, references to "one example" are not intended to be interpreted as excluding the existence of additional examples that also incorporate the recited features. Moreover, unless explicitly stated to the contrary, examples "comprising" or "having" an element or a plurality of elements having a particular condition may include additional elements not having that condition.

Examples of the present disclosure provide systems, methods, and assemblies for applying a microtextured pattern to an outer surface of an aircraft (e.g., wing surface) without requiring extensive work to the surface. Various examples provide a removably secured cover member to provide the microtextured surface. Various examples provide a sleeve or other cover that may be replaced throughout the service life of the aircraft without extensive rework of the surface, conveniently and effectively providing improved aerodynamic performance.

FIG. **1** illustrates a perspective top view of an aircraft assembly **100**. The aircraft assembly **100** includes an aircraft structure **106** and an aircraft surface cover **109** that includes a cover member **110**. The aircraft structure **106** is disposed on an exterior **104** of an aircraft **102**. For example, the aircraft structure **106** in the illustrated example is a wing **107** having a width W and a length L. It may be noted that the width W varies over length L. Other examples of aircraft structures that may be utilized in various examples include tails, flaps, or rotors (e.g., helicopter rotor blades).

The cover member **110** is removably secured to the aircraft structure **106**. "Removably secured" as used herein may be understood as meaning that the cover member **110** is attached as a unit to the aircraft structure **106** while not becoming an integral part of the aircraft structure **106**. By way of example, and for the purposes of clarity, a layer that was printed on the aircraft structure **106** would not be removably secured as used herein, at least because it was not applied as a unit. As another example, and for the purposes of clarity, a structure that were welded to the aircraft structure **106** would not removably secured as used herein, at least because welding would render the structure integral with the aircraft structure **106**. As one more example for the purposes of clarity, a surface that was machined into the aircraft structure **106** would not be removably secured as used herein, at least because such machining would make the surface an integral part of the aircraft structure **106**. Generally, removably secured cover members as discussed herein may be added to an aircraft structure **106** after the aircraft **102** has been assembled, and removed non-destructively with respect to the aircraft structure **106**, and without adversely affecting the structural integrity of the aircraft structure **106**. Further, removably secured cover members as discussed herein may be removed with minimal or no effect on the surface finish of the aircraft structure **106**. For example, in some examples, remnants of adhesive may be left on the surface after removal of a removably secured cover member. It may be noted that the removal process may be non-destructive as well with respect to the cover member **110** in various examples. For example, the cover member **110** may include a compressible sleeve that may be stretched for removal from the aircraft structure **106**. Alternatively, in other examples, the cover member **110** may be destructively removed from the aircraft structure **106**, for example by cutting through the cover member **110**.

The cover member **110** includes an exterior surface **112**. The exterior surface **112** has a microtextured surface **114**. The microtextured surface **114** is disposed on the exterior surface **112** and oriented toward an atmosphere surrounding the aircraft **102**. Accordingly, air passes over the microtextured surface **114** as the aircraft **102** moves. The microtextured surface **114** includes microtexture ribs **116** that are configured to improve aerodynamic performance of the aircraft structure **106**. For example, the microtexture ribs **116** may be configured to improve drag and/or lift. In the illustrated example, the microtexture ribs **116** are separated by grooves **118**. In various examples, the microtexture ribs **116** may have a height of about 0.5 millimeters and have about 1 millimeter spacing between adjacent ribs. While the illustrated example shows ribs extending along the entire width W, it may be noted that ribs may be shorter in other examples. In various examples, the ribs may be regularly or irregularly spaced, as well as uniformly or non-uniformly sized. Generally, the microtextured surface **114** may be provided in a predetermined pattern to provide improved aerodynamic performance, and the cover member **110** secured to the aircraft structure **106** with the microtextured surface **114** oriented in the predetermined pattern. In various examples, the microtexture ribs **116** may be configured to provide denticles or aspects of a sharkskin style surface design configured for improved aerodynamic performance.

As also discussed elsewhere herein, a variety of techniques may be used to mount or secure the cover member **110** to the aircraft structure **106**. For example, the cover member **110** may be configured as a sleeve that wraps around the aircraft structure **106**. As another example, the cover member **110** may be configured as a sheet that is adhesively joined to the aircraft structure **106**. In various examples, one or more of an elastic material, heat shrinking, or adhesives may be used to secure the cover member **110** to the aircraft structure **106**.

Accordingly, instead of being formed integrally with or permanently attached to the aircraft structure **106**, the microtextured surface **114** is disposed on the removable cover member **110**. Use of a removable cover member **110** with a microtextured surface **114** disposed thereon allows for quick and convenient replacing and/or repairing of a microtextured surface **114** without requiring extensive re-work of the aircraft structure **106** itself. The cover member **110** may be conveniently replaced periodically at pre-determined intervals or as needed.

It may be noted that the cover member **110** depicted in FIG. **1** extends along the entire width W of the aircraft structure **106** at the location along the length L at which the cover member **110** is positioned. However, in other examples, the cover member **110** may be understood as including or being configured as a partial cover that only extends along a portion (and not the entirety) of the width W. Such a partial cover may also be referred to as a bra or leading surface cover. FIG. **2** provides a perspective view of a partial cover **210** disposed on the aircraft structure **106** in accordance with various examples. The partial cover **210** may be understood as an example of cover member **110**, and includes microtextured ribs on an exterior surface as discussed above. As seen in FIG. **2**, the depicted partial cover **210** is configured (e.g., sized and shaped) to cover a leading portion **206** of the aircraft structure **106** (e.g., a portion of the aircraft structure **106** oriented toward the direction of travel). As seen in FIG. **2**, the partial cover **210** does not extend along the entire width W of the aircraft structure **106**. Instead, the partial cover **210** only extends along a portion **212** of the width W, resulting in a covered portion **220** and an uncovered portion **222** of the aircraft structure **106**. In the example depicted in FIG. **2**, the partial cover **210** includes loops **230** to help secure and/or maintain the partial cover **210** in place. Alternatively or additionally, an adhesive may be used to secure the partial cover **210** in place, for example. Use of a partial cover **210** allows for efficient placement of microtextured surfaces of the partial cover **210** toward a front or leading surface of the aircraft structure **106** while allowing for a relatively small cover and/or allowing access to a larger portion of the surface of the aircraft structure **106**.

In various examples, the cover member includes or is configured as a sleeve that is configured (e.g., sized and shaped) to extend around a circumference of the aircraft structure. FIG. **3** provides a cross-sectional view of a sleeve **310** disposed around a circumference **306** of an aircraft structure **106**. The sleeve **310** may be understood as an example of the cover member **110**. As seen in FIG. **3**, in contrast to the partial cover **210** of FIG. **2**, the sleeve **310** depicted in FIG. **3** extends along the entire circumference **306** of the aircraft structure **106** to define a closed loop around a cross-section of the aircraft structure **106** taken at a point along its length L. It may be noted that the sleeve **310** has an upper exterior surface portion **311** and a lower exterior surface portion **312**. A microtextured surface as discussed herein is disposed on at least one of the upper exterior surface portion **311** or lower exterior surface portion **312**. In various examples, a microtextured surface may be disposed on all or a portion of the upper exterior surface portion **311** and/or lower exterior surface portion **312**. It may be noted that in various examples an upper microtextured surface **313** (disposed on all or a portion of the upper exterior surface portion **311**) may be configured differently than a lower microtextured surface **314** (disposed on all or a portion of the lower exterior surface portion **312**) to impart different aerodynamic properties for the upper and lower surfaces. Use of a sleeve **310** allows for provision of microtextured surfaces over a large (or entire) portion of an aircraft structure **106**.

In various examples, the sleeve **310** may be made of an elastic material. FIG. **4** provides a side view of an elastic sleeve **400** in accordance with various examples. The elastic sleeve **400** of FIG. **4** may be understood as an example of the sleeve **310** of FIG. **3**. As seen in FIG. **4**, in which the sleeve **400** is shown in an unstretched condition, the sleeve **400** has a nominal pre-application cross-sectional area **420**. The nominal pre-application cross-sectional area **420** is smaller than a corresponding cross-sectional area **320** (e.g., a cross-sectional area of the aircraft structure at which the cross-section of the elastic sleeve **400** will be located) of the aircraft structure **106** (see FIG. **3**). Accordingly, to place the sleeve **400** on the aircraft structure **106**, the elastic sleeve **400** is stretched to increase its cross-sectional area, and pulled over an end of the aircraft structure **106** to a desired end location, at which point the elastic sleeve **400** is allowed to compress under its elasticity about the aircraft structure **106**, securing the elastic sleeve **400** in place. To remove the elastic sleeve **400**, the elastic sleeve **400** is stretched to increase its cross-sectional area and pulled off of the aircraft structure **106**. Accordingly, the elastic sleeve **400** may be conveniently placed on the aircraft structure **106** and non-destructively removed. It may be noted that the cross-sectional area of the elastic sleeve **400** may be tapered along the length L to match a taper of the cross-sectional area of the aircraft structure **106**.

In various examples, the sleeve **310** may be made of a heat shrinkable material, and be applied as a pre-formed sleeve that has a slightly larger cross-sectional area than a corresponding portion of the aircraft structure **106**, and is shrunk to fit the aircraft structure **106** once in place. In other examples, the sleeve **310** may be initially formed as a sheet that is subsequently heat-shrunk onto the aircraft structure **106**. For example, FIGS. **5** and **6** provide side schematic views of a sheet **500** used to form a sleeve **310** in accordance with various examples. As seen in FIG. **5**, the sheet **500** has a first edge **502** and a second edge **504** opposite the first edge **502**, as well as an exterior surface **506**. A microtextured surface as discussed herein is disposed on the exterior surface **506**, and the sheet **500** is made of a heat-shrinkable material. As seen in FIG. **6**, the sheet **500** is joined at an edge (e.g., first edge **502** is joined to second edge **504**) after the sheet is disposed around the aircraft structure **106**. A gap **600** is shown between the sheet **500** that has been formed into a sleeve **310** and the aircraft structure **106**. Once the sleeve **310** is formed and in place, the sleeve **310** may be heat shrunk to be secured to the aircraft structure **106**. It may be noted that the ends need not be joined to each other. For example, one end could be joined to an intermediate portion of the sheet, with the portion between the intermediate portion and other end trimmed off after joining, allowing for a more close, customizable fit to a particular size or shape of aircraft structure using a pre-formed sheet. It may be noted that the gap **600** shown in FIG. **6** is fairly large for ease and clarity of illustration; however, the actual gap may be sized to allow for 10% or less shrinkage. Further, in various examples, the sheet **500** may be configured to shrink more along one direction than one or more other directions (e.g., configured to shrink more along the width instead of the length).

It may be noted that in various examples, the aircraft structure **106** may have portions (e.g., projections) that are difficult or impractical to cover with a sleeve or other cover member. For example, FIG. **7** depicts an aircraft structure **106** with features **706** (the features are projections in the illustrated example), and a sleeve **710** that includes openings **712** configured to extend around the features **706** of the aircraft structure **106**. The sleeve **710** may be understood as an example of the sleeve **310** and includes microtextured surfaces on at least a portion of its exterior surface. The openings **712** may be configured to fit around engine mounts, movable flaps, pitot tubes or other sensing devices, lights, or other features of the aircraft structure **106** that are inappropriate or inconvenient to cover.

In various examples, the cover member **110** (e.g., sleeve **310**) may not cover an entire length of the aircraft structure **106**. For example, for the example illustrated in FIG. **1**, the cover member **110** has a length **111** that is less than the corresponding length L of the aircraft structure **106**, with the cover member **110** covering only a portion of the aircraft structure **106** along the length L of the aircraft structure **106**. The sleeve **710** of FIG. **7** provides another example of a cover member that has a length that is less than the corresponding length L of the aircraft structure **106**.

It may be noted that in other examples, the cover member **110** may cover an entire length of an aircraft structure **106** (e.g., airfoil). For example, FIG. **8** provides a perspective view of a helicopter blade **800** having an airfoil **802**, with a cover **810** extending along the entire length **804** of the airfoil **802**. The cover **810** may be understood as an example of the cover member **110**, and includes a microtextured surface as discussed herein.

It may further be noted that in various examples one or both of the cover member **110** and aircraft structure **106** includes one or more locating features configured to help ensure proper positioning or placement of the cover member **110** on the aircraft structure **106**. For example, as seen in FIG. **1**, the cover member **110** includes a cover locating feature **190** that is configured to cooperate with a corresponding feature **192** of the aircraft structure **106** for locating the cover member **110** relative to the aircraft structure **106**. In the illustrated example, the cover locating feature **190** and corresponding feature **192** are configured to be disposed adjacent to one another when the cover member **110** is positioned in a desired placement; however, it may be noted that other predetermined relationships may be utilized. For example, the cover locating feature **190** may be configured to be placed directly over the corresponding feature **192**. It may be noted that the corresponding feature **192** may be printed, painted, or applied as a decal to the aircraft structure **106** in some examples. Alternatively or additionally, an existing structural component (e.g., engine mount, edge or corner of a structure, edge of a flap, or the like) of the aircraft structure **106** may be used in cooperation with the cover locating feature **190**.

FIG. **9** illustrates a flowchart of a method **900** for improving aerodynamic performance of an aircraft structure. The method **900**, for example, may employ structures or aspects of various examples (e.g., systems and/or methods) discussed herein. In various examples, certain steps (or operations) may be omitted or added, certain steps may be combined, certain steps may be performed simultaneously, certain steps may be performed concurrently, certain steps may be split into multiple steps, certain steps may be performed in a different order, or certain steps or series of steps may be re-performed in an iterative fashion.

At **902**, a cover member (e.g., cover member **110**) is provided. The cover member includes an exterior surface having a microtextured surface that includes microtexture ribs as discussed herein. The microtexture ribs are configured to improve the aerodynamic performance of an aircraft structure (e.g., aircraft structure **106**) to which the cover member will be mounted. Various techniques may be employed to form the cover member, which may be formed as a sheet (e.g., sheet **500**), for example, or a partial cover (e.g., partial cover **210**), as another example, or a sleeve (e.g., sleeve **310**) as another example. The cover member in various examples may be made of an elastic and/or heat-shrinkable material. In the illustrated example, at **904**, the microtexture ribs are formed on the exterior surface of sleeve using at least one of extruding or pressing.

At **906** of the illustrated example, the cover member is located at a predetermined position relative to the aircraft structure. In various examples, a cover locating feature of the cover member that cooperates with a corresponding feature of the aircraft structure is used to locate the cover member at the predetermined position. Locating the cover member in a predetermined position in various examples also includes orienting microtextured protrusions (or ribs) in a predetermined pattern relative to the aircraft structure to provide improved aerodynamic performance.

At **908**, openings of the cover member are positioned around features of the aircraft structure when positioning the cover member. For example, in examples utilizing a sheet, the openings may be positioned around the features when the sheet is wrapped around the circumference of the aircraft structure (e.g., to form a sleeve). It may be noted that this step may be omitted for cover members that are not placed near or around any features that are undesirable or impractical to cover.

In some examples, an intermediate filler layer may be utilized, for example, to improve fit and/or adhesion between the cover member and the aircraft structure, to ease removal of the cover member, and/or to protect the aircraft structure. In the illustrated example, at **910**, an intermediate filler layer is applied to a surface of the aircraft structure before securing the cover member.

At **912**, the cover member is secured to the aircraft structure. As discussed herein, in various examples, the cover member is removably secured to the aircraft structure. Various techniques may be employed in various examples to secure the cover member to the aircraft structure.

For example, in some examples, at **914**, a partial cover (e.g., partial cover **210**) is adhesively joined to a leading portion of the aircraft structure.

As another example, in some examples the cover member includes or is configured as a sleeve made of an elastic material. For such a sleeve, at **916**, the sleeve is elastically stretched over the aircraft structure, and allowed to constrict onto the aircraft structure to secure the sleeve to the aircraft structure.

As another example, in some examples, a heat-shrinkable material is used. For example, at **918**, a sheet is wrapped around a circumference of the aircraft structure. At **920**, ends of the sheet are joined to each other to form a sleeve. At **922**, heat is applied to shrink the sleeve onto the aircraft structure.

As noted herein, in various examples, the cover member is removably secured to the aircraft structure. For example, in the illustrated example, at **924**, the cover member is removed from the aircraft structure. Removal of the cover member allows for repair and/or replacement of the cover member without having to re-work any surfaces of the aircraft structure, reducing the time and cost of maintenance of a microtextured surface for an aircraft structure. In some examples, the cover member may be removed without damaging the cover member, for example, by stretching an elastic material of the cover member to pull the cover member off of a wing or other aircraft structure to which it was mounted.

Examples of the disclosure may be described in the context of an aircraft manufacturing and service method **1100** as shown in FIG. **10** and an aircraft **1200** as shown in FIG. **11**. During pre-production, illustrative method **1100** may include specification and design **1102** of the aircraft **1200** and material procurement **1104**. During production, component and subassembly manufacturing **1106** and system integration **1108** of the aircraft **1200** take place. Thereafter, the aircraft **1200** may go through certification and delivery **1110** to be placed in service **1112**. While in service by a customer, the aircraft **1200** is scheduled for routine maintenance and service **1114** (which may also include modification, reconfiguration, refurbishment, and so on).

Each of the processes of the illustrative method **1100** may be performed or carried out by a system integrator, a third party, and/or an operator (e.g., a customer). For the purposes of this description, a system integrator may include, without limitation, any number of aircraft manufacturers and major-system subcontractors; a third party may include, without limitation, any number of vendors, subcontractors, and suppliers; and an operator may be an airline, leasing company, military entity, service organization, and so on.

As shown in FIG. **11**, the aircraft **1200** produced by the illustrative method **1100** may include an airframe **1202** with a plurality of high-level systems **1204** and an interior **1206**. Examples of high-level systems **1204** include one or more of a propulsion system **1208**, an electrical system **1210**, a hydraulic system **1212**, and an environmental system **1214**. Any number of other systems may be included. Although an aerospace example is shown, the principles of the disclosure may be applied to other industries, such as the automotive industry. Accordingly, in addition to aircraft **1200**, the principles disclosed herein may apply to other vehicles, e.g., land vehicles, marine vehicles, space vehicles, etc.

Apparatus and methods shown or described herein may be employed during any one or more of the stages of the manufacturing and service method **1100**. For example, components or subassemblies corresponding to component and subassembly manufacturing **1106** may be fabricated or manufactured in a manner similar to components or subassemblies produced while the aircraft **1200** is in service. Also, one or more aspects of the apparatus, method, or combination thereof may be utilized during the production stages **1106** and **1108**, for example, by substantially expediting assembly of or reducing the cost of an aircraft **1200**. Similarly, one or more aspects of the apparatus or method realizations, or a combination thereof, may be utilized, for example and without limitation, while the aircraft **1200** is in service, e.g., maintenance and service **1114**.

While various spatial and directional terms, such as top, bottom, lower, mid, lateral, horizontal, vertical, front and the like may be used to describe examples of the present disclosure, it is understood that such terms are merely used with respect to the orientations shown in the drawings. The orientations may be inverted, rotated, or otherwise changed, such that an upper portion is a lower portion, and vice versa, horizontal becomes vertical, and the like.

As used herein, a structure, limitation, or element that is “configured to” perform a task or operation is particularly structurally formed, constructed, or adapted in a manner corresponding to the task or operation. For purposes of clarity and the avoidance of doubt, an object that is merely capable of being modified to perform the task or operation is not “configured to” perform the task or operation as used herein.

It is to be understood that the above description is intended to be illustrative, and not restrictive. For example, the above-described examples (and/or aspects thereof) may be used in combination with each other. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the various examples of the disclosure without departing from their scope. While the dimensions and types of materials described herein are intended to define the parameters of the various examples of the disclosure, the examples are by no means limiting and are exemplary examples. Many other examples will be apparent to those of skill in the art upon reviewing the above description. The scope of the various examples of the disclosure should, therefore, be determined with reference to the appended claims, along with the full scope of equivalents to which such claims are entitled. In the appended claims, the terms "including" and "in which" are used as the plain-English equivalents of the respective terms "comprising" and "wherein." Moreover, the terms "first," "second," and "third," etc. are used merely as labels, and are not intended to impose numerical requirements on their objects. Further, the limitations of the following claims are not written in means-plus-function format and are not intended to be interpreted based on 35 U.S.C. § 112(f), unless and until such claim limitations expressly use the phrase "means for" followed by a statement of function void of further structure.

This written description uses examples to disclose the various examples of the disclosure, including the best mode, and also to enable any person skilled in the art to practice the various examples of the disclosure, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the various examples of the disclosure is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if the examples have structural elements that do not differ from the literal language of the claims, or if the examples include equivalent structural elements with insubstantial differences from the literal language of the claims.

What is claimed is:

1. An aircraft surface cover comprising:

a cover member configured to be removably secured to an airfoil structure, the cover member comprising an exterior surface, the exterior surface having a microtextured surface comprising microtexture ribs configured to improve aerodynamic performance of the airfoil structure,

wherein the cover member comprises a sleeve configured to extend around a circumference of the airfoil structure, and

wherein the sleeve is made of an elastic material, the sleeve having a nominal pre-application cross-sectional area that is smaller than a corresponding cross-sectional area of the airfoil structure.

2. The aircraft surface cover of claim **1**, wherein the cover member comprises a partial cover configured to cover a leading portion of the airfoil structure, the partial cover configured to be adhesively joined to the airfoil structure.

3. The aircraft surface cover of claim **1**, wherein the sleeve is made of a heat-shrinkable material, wherein the sleeve comprises a sheet configured to be joined at an edge when disposed around the airfoil structure.

4. The aircraft surface cover of claim **1**, wherein the sleeve includes openings configured to extend around features of the airfoil structure.

5. The aircraft surface cover of claim **1**, wherein the sleeve has a length that is less than a corresponding length of the airfoil structure, wherein the sleeve is configured to cover only a portion of the airfoil structure.

6. The aircraft surface cover of claim **1**, further comprising a cover locating feature configured to cooperate with a corresponding feature of the airfoil structure for locating the cover member relative to the airfoil structure.

7. The aircraft surface cover of claim **1**, wherein the microtexture ribs have a height that does not exceed 0.5 millimeters, and wherein a spacing between adjacent microtexture ribs does not exceed 1 millimeter.

8. The aircraft surface cover of claim **1**, wherein the sleeve has the nominal pre-application cross-sectional area that is smaller than a corresponding cross-sectional area of the airfoil structure before the sleeve is disposed around the circumference of the airfoil structure.

9. The aircraft surface cover of claim **1**, wherein to place the sleeve on the airfoil structure, the sleeve is stretched to increase the cross-sectional area, and pulled over an end of the airfoil structure to a desired end location, at which point the sleeve is allowed to compress under elasticity about the airfoil structure, securing the sleeve in place.

10. A method of improving aerodynamic performance of an airfoil structure, the method comprising:

providing a cover member comprising an exterior surface, the exterior surface having a microtextured surface comprising microtexture ribs configured to improve aerodynamic performance of the airfoil structure; and

securing the cover member to the airfoil structure, wherein the cover member comprises a sleeve made of an elastic material, the sleeve having a nominal pre-application cross-sectional area that is smaller than a corresponding cross-sectional area of the airfoil structure, wherein said securing the cover member comprises elastically stretching the sleeve over the airfoil structure, and allowing the sleeve to constrict onto the airfoil structure.

11. The method of claim **10**, wherein securing the cover member comprises adhesively joining a partial cover to a leading portion of the airfoil structure.

12. The method of claim **10**, wherein the sleeve comprises a sheet of heat-shrinkable material, wherein securing the cover member comprises:

wrapping the sheet around a circumference of the airfoil structure;

joining ends of the sheet to each other; and

applying heat to shrink the sleeve onto the airfoil structure.

13. The method of claim **12**, further comprising positioning openings of the sleeve around features of the airfoil structure when wrapping the sheet around the circumference of the airfoil structure.

14. The method of claim **10**, further comprising locating the cover member at a predetermined position relative to the airfoil structure via a cover locating feature that cooperates with a corresponding feature of the airfoil structure.

15. The method of claim **10**, further comprising removing the cover member from the airfoil structure.

16. The method of claim **10**, further comprising applying an intermediate filler layer to a surface of the airfoil structure before securing the cover member.

17. The method of claim **10**, further comprising forming the microtexture ribs on the exterior surface of the sleeve using at least one of extruding or pressing.

18. The method of claim **10**, wherein the sleeve has the nominal pre-application cross-sectional area that is smaller than a corresponding cross-sectional area of the airfoil structure before the sleeve is disposed around the circumference of the airfoil structure.

19. An aircraft assembly comprising:

an airfoil structure disposed on an exterior of an aircraft; and

a cover member removably secured to the airfoil structure, the cover member comprising an exterior surface, the exterior surface having a microtextured surface comprising microtexture ribs configured to improve aerodynamic performance of the airfoil structure,

wherein the cover member comprises a sleeve extending around a circumference of the airfoil structure, the sleeve having a nominal pre-application cross-sectional area that is smaller than a corresponding cross-sectional area of the airfoil structure.

20. The aircraft assembly of claim **19**, wherein the cover member comprises a partial cover that covers a leading portion of the airfoil structure.

21. The aircraft assembly of claim **19**, wherein the sleeve has the nominal pre-application cross-sectional area that is smaller than a corresponding cross-sectional area of the airfoil structure before the sleeve is disposed around the circumference of the airfoil structure, and wherein to place the sleeve on the airfoil structure, the sleeve is stretched to increase the cross-sectional area, and pulled over an end of the airfoil structure to a desired end location, at which point the sleeve is allowed to compress under elasticity about the airfoil structure, securing the sleeve in place.

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